Adjusting Mixtures to Meet BMD

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National Center for Asphalt Technology (NCAT)

Mid-Atlantic Asphalt Expo & Conference

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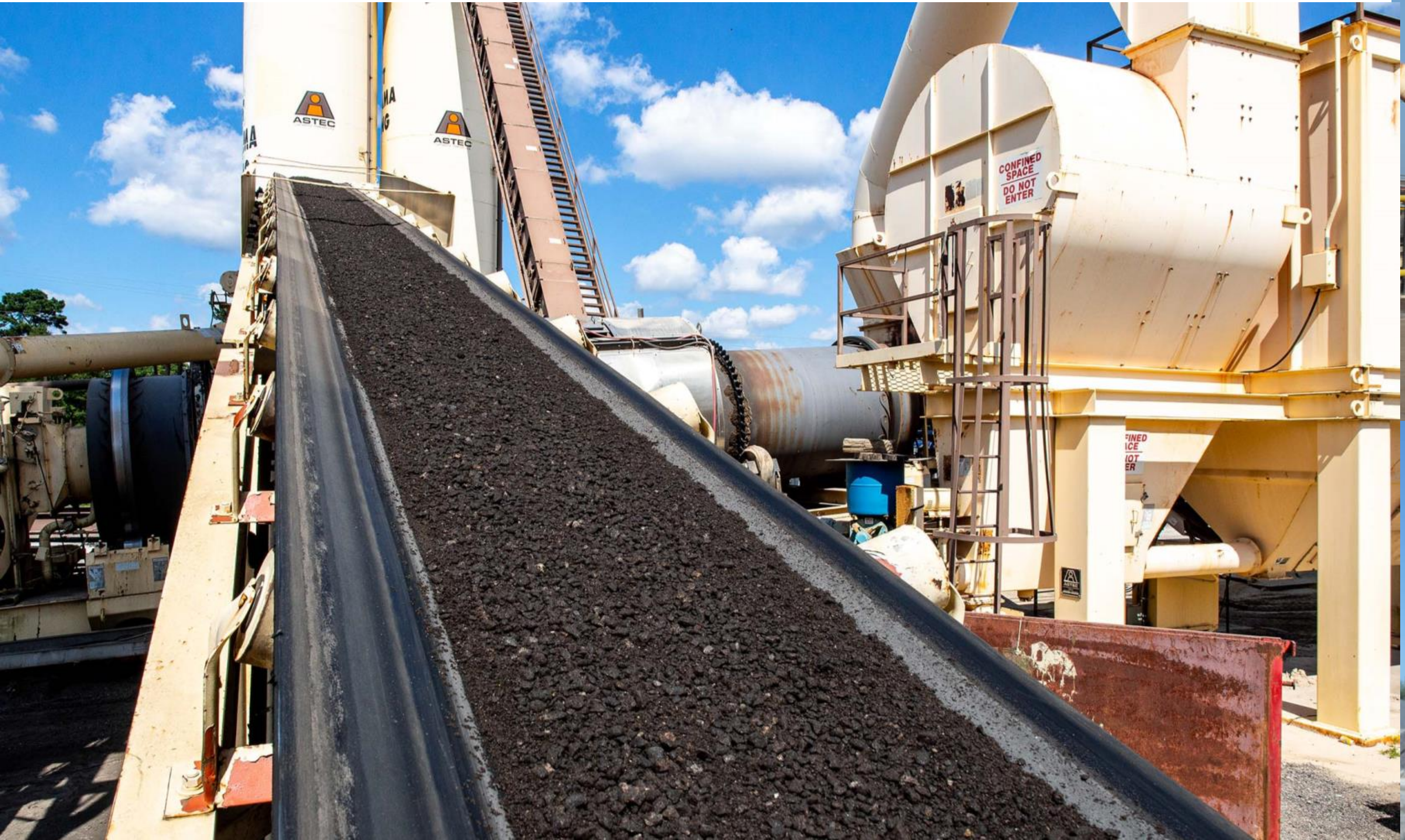
How do we get from here…

to here?



Or how do we fix this?

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National Center for Asphalt Technology Job-Mix Formula

NCAT Project ID:	TT 2021 Additive Group Phase I	NCAT Mix ID:	Phase I Control Mix
Principal Investigator:	Buzz Powell	Mix Design Engineer:	Nathan Moore
		Design Completion Date:	11/19/2020
Mix Type:	Dense-Graded Superpave	Virgin Binder Grade:	PG 76-22
Nom. Max Agg. (NMAS):	12.5mm (1/2")		

AASHTO Superpave Volumetric Mix Design

Cold Feed %	Aggregate Description	Source	Gsb	Gsa	% Abs.
26	Granite 78's	[redacted]	2.627	2.674	0.7
25	Granite 89's	[redacted]	2.601	2.679	1.1
28	Manufactured Sand	[redacted]	2.639	2.662	0.3
20	RAP	[redacted]	2.632	2.680	0.7
1	Baghouse Fines	NCAT	2.644	2.683	0.5

Job Mix

Sieve	Sieve	% Passing
1 1/2"	(37.5 mm)	100.0
1"	(25 mm)	100.0
3/4"	(19.0 mm)	100.0
1/2"	(12.5 mm)	98.3
3/8"	(9.5 mm)	89.2
#4	(4.75 mm)	55.0
#8	(2.36 mm)	41.1
#16	(1.18 mm)	32.7
#30	(600 µm)	22.4
#50	(300 µm)	11.7
#100	(150 µm)	6.7
#200	(75 µm)	4.45

Volumetric Information

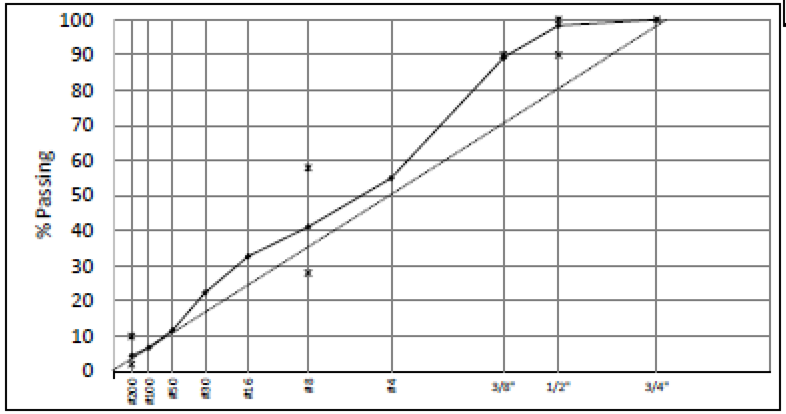
% Total AC Required	5.60
Max Spec. Gravity Mix (Gmm)	2.453
Bulk Spec. Gravity Mix (Gmb)	2.344
Design Air Voids (Va)	4.4
VMA	15.9
VFA	71.8
Dust/Asphalt Ratio	0.89
Effective AC (Pbe)	4.98
Absorbed AC (Pba)	0.66
% AC Contribution from RAP	1.15
% AC Contribution from RAS	0.00
% Virgin Binder	4.45
% Recycled AC Replacement	20.5

Aggregate Information

Agg. Bulk Gravity (Gsb)	2.627
Agg. Effective Gravity (Gse)	2.672
Agg. Apparent Gravity (Gsa)	2.674
Agg. Absorption (Abs)	0.66
Coarse Agg. Angularity (1)	100 assumed*
Coarse Agg. Angularity (2+)	100 assumed*
Fine Agg. Angularity (FAA)	45
Flat and Elongated 5:1 (F & E)	0
Sand Equivalency (SE)	98

Other Information

Ndes Gyrations	60
Design Sample Mass, g	4700
Mix Ign CF	-0.29



Presentation Outline

What mix design variables can be changed to improve

- Rutting resistance
- Cracking resistance
- Moisture susceptibility

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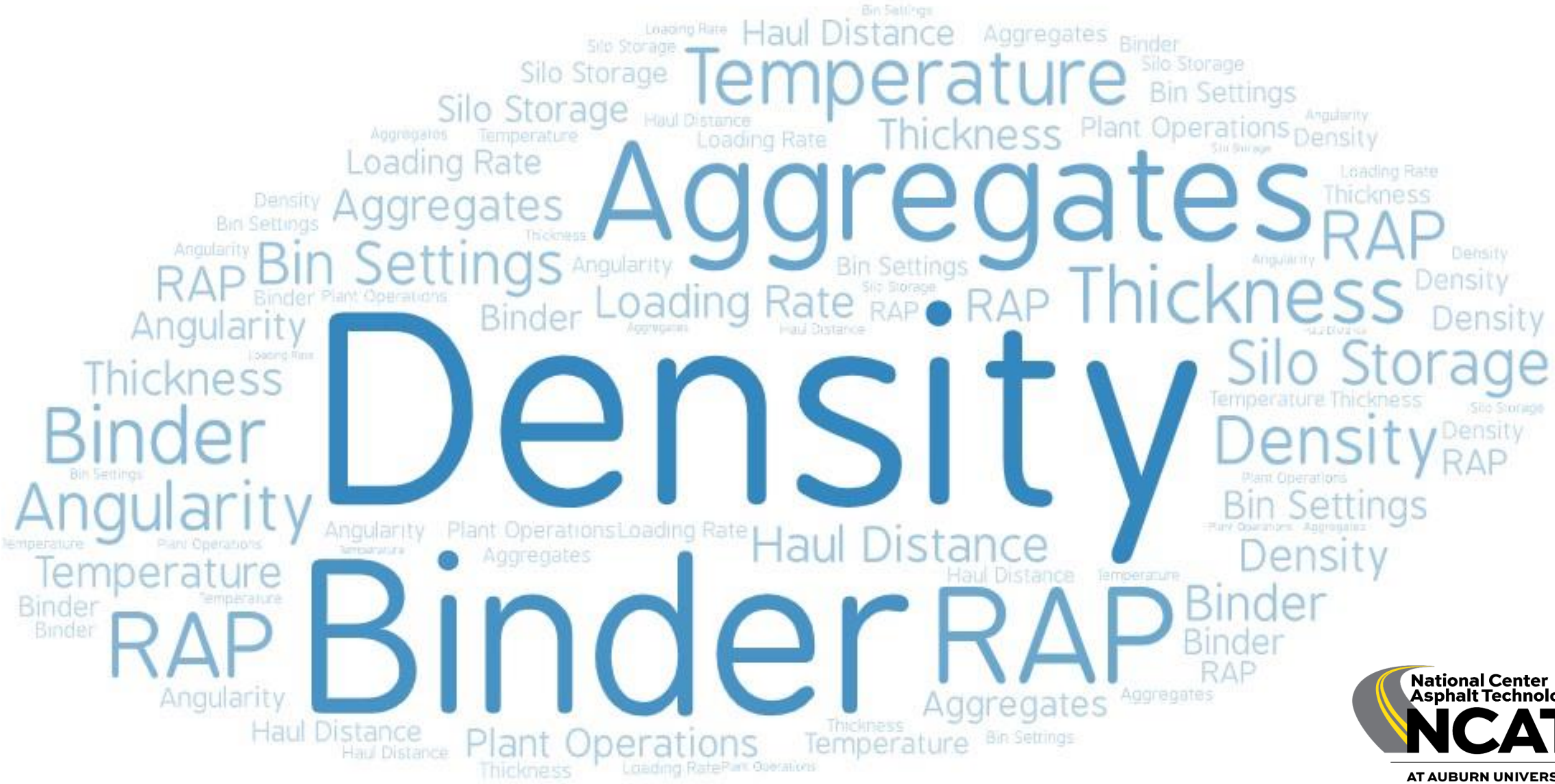
Asphalt Pavement Performance



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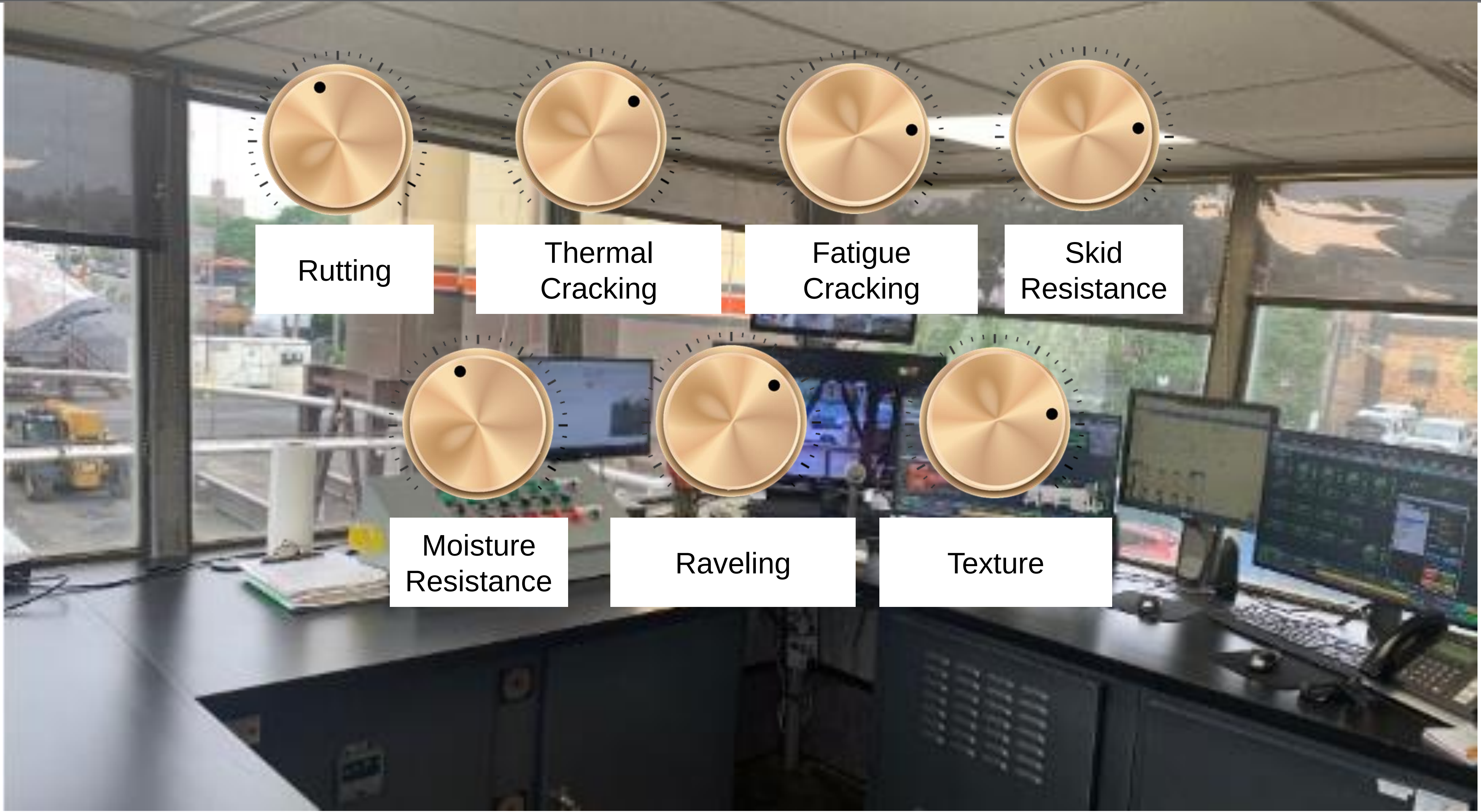
What can we actually control?

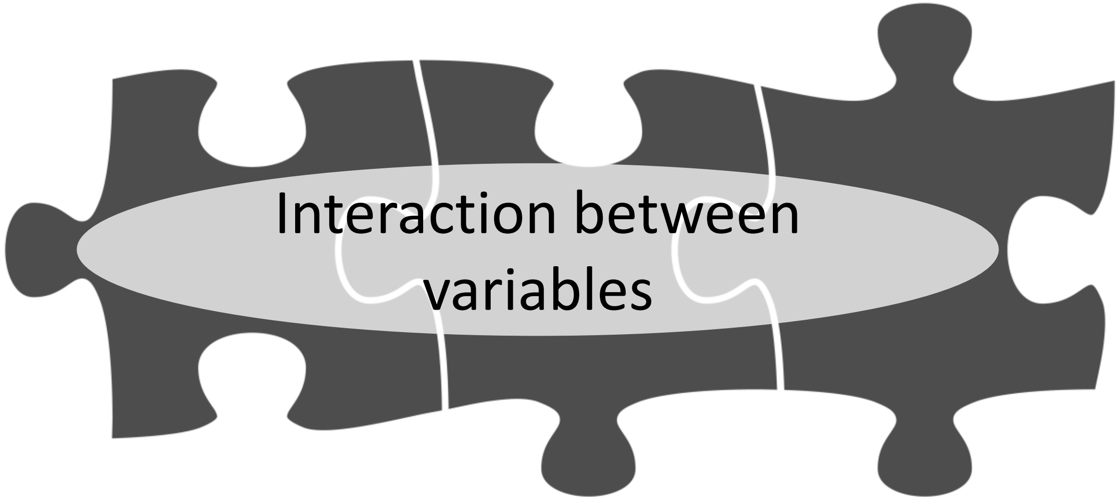


What mix design variables affect performance?

Binder
- Binder content
- Binder grade
- Crude source
- Anti-strip
- Additives

Aggregate
- Gradation
- Angularity
- Strength
- Dust

Recycled
- RAP content
- RAS content
- Binder grade
- Plastics
- Rubber
- Fibers



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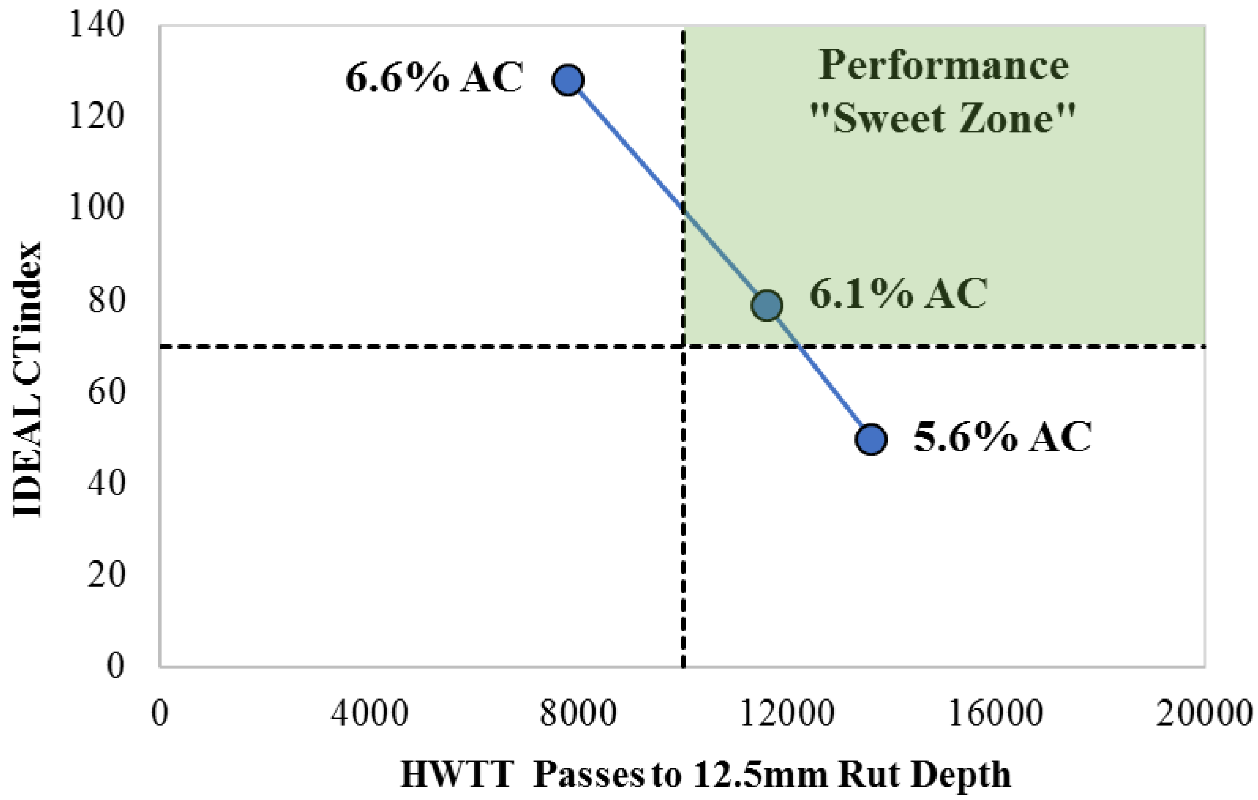
Rutting

- Adjusting aggregate gradation
- Using a stiffer asphalt binder
- Polymer modification
- Lowering asphalt content
- Increasing recycled materials content
- Adding fiber additives

Rutting: Case Study 1

- Factor: binder content
- Hamburg Wheel Tracking Test (HWTT)



Virgin Mix

PG 67-22 Binder

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Rutting: Case Study 2

- Factor: binder grade
- Asphalt Pavement Analyzer

Binder Type	APA Rut Depth (mm)
PG 64-22	3.8
PG 70-22	2.4
PG 76-22 (SBS)	1.4

12.5 mm NMAS
Virgin Mix

(Data from Zaniewski, 2003)

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Rutting: Case Study 3

- Factors: RAP content, binder content
- HWTT

Binder Content	HWTT Rut Depth (mm)	
	35% RAP mix, PG 64-34 binder	45% RAP mix, PG 64-34 binder
4.3%	3.0	2.4
4.8%	4.0	3.2
5.3%	4.7	3.8

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Rutting: Case Study 4

- Factor: Coarse Aggregate Type
- Hamburg Wheel-Tracking Test (HWTT)

Agg Type	HWTT Rutting (mm)
Natural Gravel	8.7
Limestone	7.1

19% RAP Mix
PG 58-28
5.8% AC

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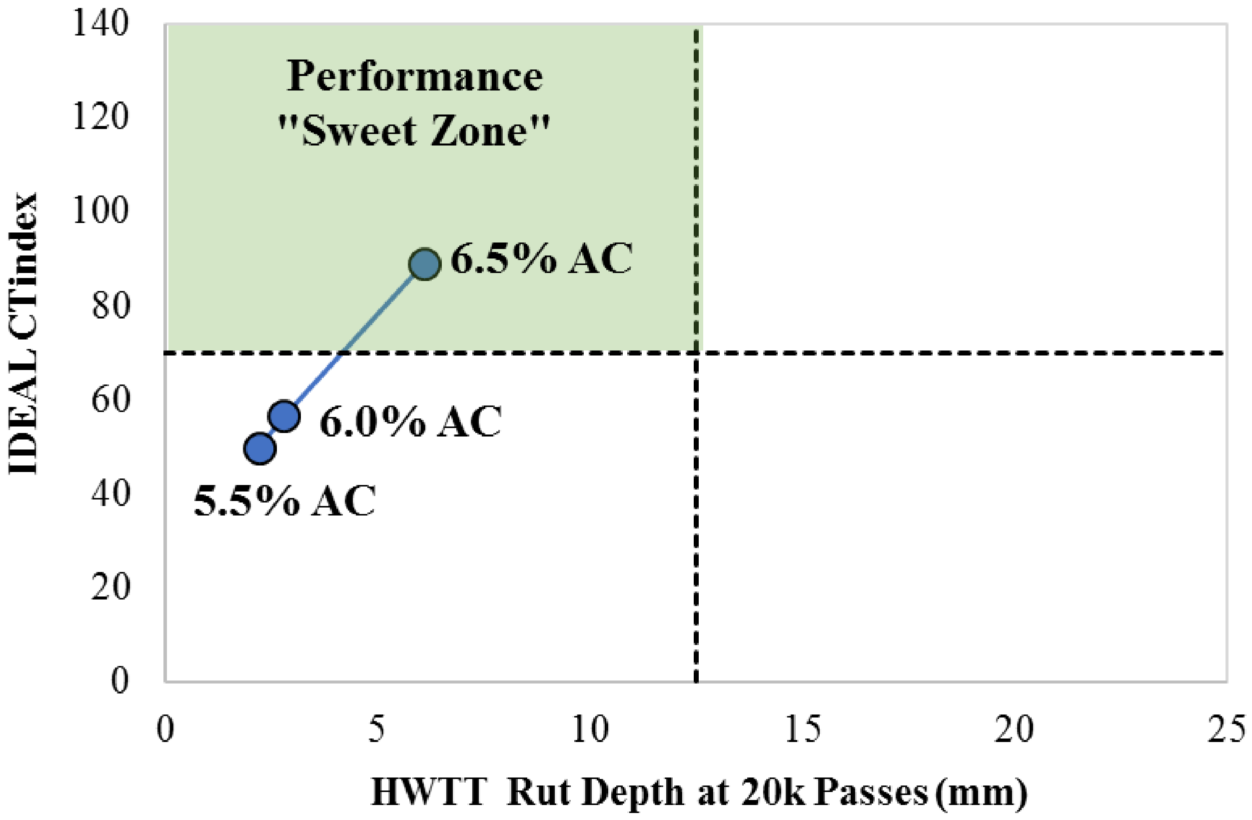
Cracking

- Increasing asphalt content or V_{be}
- Lowering recycled materials content
- Using a softer (better quality) asphalt binder
- Adding a rejuvenator or other additive
- Change crude source

Cracking: Case Study 1

- Factor: binder content
- Indirect Tensile Asphalt Cracking Test (IDEAL-CT)



20% RAP Mix

PG 67-22 Binder

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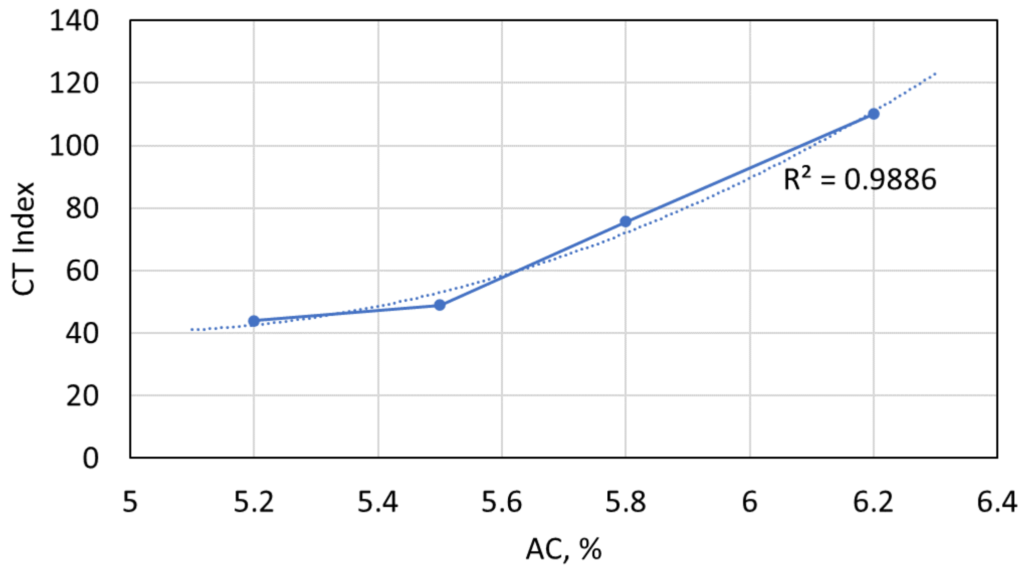
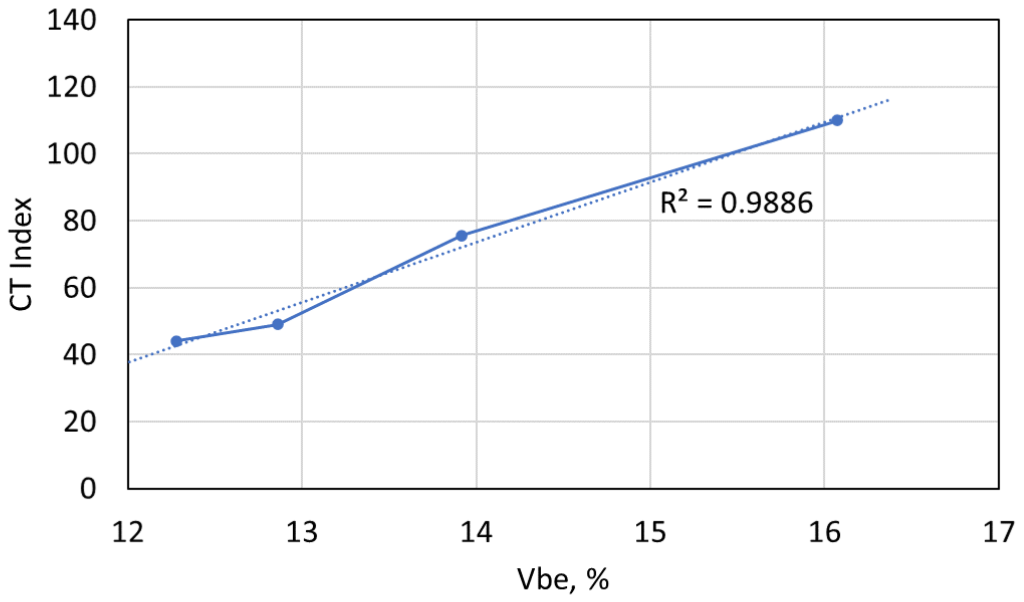
Cracking: Case Study 2

- Factor: Volume of Effective Binder (V_{be}) @ Ndes
- IDEAL-CT





20% RAP Mix

PG 76-22

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Cracking: Case Study 3

- Factors: RAP content
- IDEAL-CT & Hamburg Wheel Tracking Test (HWTT)

RAP Content	Laboratory Test Result	
	IDEAL-CT	HWTT Rutting (mm)
0%	124	5.6
15%	77	3.0
30%	37	2.1

PG 70-28

4.7 – 5.0% AC

Cracking: Case Study 3

- Factor: rejuvenator dosage
- IDEAL-CT

Rejuvenator Dosage	CT_{index}
No rejuvenator	21.1
Low	38.1
Medium	44.1
High	42.2

45% RAP Mix

PG 64-22

5.2% AC

Cracking: Case Study 4

- Factor: softer binder
- I-FIT

Low-temperature PG	Flexibility Index	
	4h@135C on loose mix	5d@85C on loose mix
xx-22	4.0	1.7
xx-28	5.8	3.0
xx-34	9.0	5.1

(Data from Bonaquist, 2016)

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Cracking: Case Study 5

- Factor: Coarse aggregate source
- IDEAL, I-FIT, & DCT

Aggregate Type	Laboratory Result		
	IDEAL-CT	I-FIT	DCT (J/m^2)
Natural Gravel	83	12.1	597
Limestone	64	7.4	361

19% RAP Mix

PG 58-28

5.3% AC

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Stripping

- Changing binder source
- Changing aggregate type
- Adding/changing an anti-strip agent

Stripping: Case Study 1

- Factor: binder source
- HWTT

Binder Source	HWTT Rut Depth at 20k Passes
Source A	3.0 mm
Source B	> 12.5 mm

15% RAP Mix

PG 76-28

5.6% AC

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Stripping: Case Study 2

- Factor: liquid anti-strip additive
- Tensile Strength Ratio (TSR)
- Virgin mix, granite aggregate (with known stripping issues), 5.4% AC

Liquid Anti-strip	TSR
No Anti-strip	0.26
+ Product A	0.67
+ Product B	0.85

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Factors to Consider for Design Optimization

Performance

Cost

Material Availability

Closing Remarks

- "When faced with a problem with multiple solutions, begin with the simplest approach first"
- Example: Failing mix design. Need 15 more CT_{Index} units
  - Are data repeatable? Do they make sense based off of historical results?
  - Change gradation? RAP source? Aggregates?
  - Identify different binder source? Binder grade? Decrease RAP content?
  - Additives, Fibers, Oils, Recycling Agents (These are not bad!)
  - What is the simplest/cheapest approach that gets the job done?

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NCAT Test Track Conference – May 7-9, 2024

Thank you!
Questions?

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